Protocol: Weather and climate
Parks: MORA, NOCA, OLYM, FOCL, SAJH, EBLA, FOVA

Justification:
Meteorologic data are essential to understanding and interpreting ecosystem trends that will be detected from all aspects of the NCCN long-term monitoring program. They are important factors governing the activity of organisms and community composition. The atmosphere is critical to the cycling of elements, nutrients, and minerals through ecosystems, and delivers pollutants from regional and global sources. Information obtained from meteorologic monitoring will be useful to interpreting and understanding changes in species composition, community structure, water and soil chemistry, and related landscape processes.

The dynamic nature of weather and its meteorologic and atmospheric agents demonstrate the need for an on-site, comprehensive, long-term monitoring program. Spatially, the seven parks are distributed across a diverse landscape and range of climatic conditions. Several climate zones exist as a function of elevation, topography, and distance from the Pacific Ocean within the NCCN. The potential for long-term changes in the global atmospheric environment to affect park resources is high given recent changes in glacial cover and the sensitivity of the region to climate change. Increased temperature and altered precipitation patterns, which are currently predicted for the next century as the result of increased greenhouse gases, would have significant effects on the distribution and abundance of terrestrial and aquatic biota, and ecosystem processes such as carbon cycling. Increased ultraviolet radiation could also affect the physiological function and mutagenic rates of some organisms. Ecosystem responses to climate and related hydrologic and landscape processes will be monitored through the vegetation, aquatic, marine, and, air quality, water quality, and glacier programs.

Monitoring Objectives:
- Determine the parkwide spatial (climate zone, elevation, aspect), and temporal (monthly, seasonal, annual, decadal) trends in air temperature, precipitation (including snow, snow depth, and snow water equivalent (SWE)) , wind speed, wind direction, soil moisture, relative humidity and solar radiation in each Network park.
- Determine the parkwide trend in the annual and decadal extent of snowpack in MORA, NOCA and OLYM.
- Determine the parkwide spatial, and annual and decadal trend in lake ice-out in MORA, NOCA and OLYM (index lakes are the sites selected by the aquatic technical working group for monitoring long-term trends in montane lakes and ponds).
- Determine the seasonal, annual and decadal trend in UV radiation at one site in OLYM.

Monitoring Approach:
How is it measured?
Climate/weather will be measured using a variety of meteorological (met) stations, some of which already exist in or adjacent to Network parks. Micro-monitors will be used to monitor lake ice-out, remote sensing will be used to monitor snowpack extent. Meteorological stations come with an array of instrumentation including air temp., precipitation, wind speed, wind direction, and relative humidity. Solar radiation, photosynthetically-active radiation **(**PAR), and soil moisture can be added where needed.

Parameters for Met Stations:
First Priority: Air temperature, Precipitation – includes snow if a higher elevation site (SWE, snow depth)
Second Priority: Wind Speed/Direction, Relative Humidity
Third Priority: Soil Moisture, Solar Radiation
Fourth Priority: Continue UV monitoring at OLYM

What is measured	How	When
Temp, precipitation, SWE, snow depth, wind, RH, radiation;	weather stations, SNOTEL sites	year round, hourly – may be summarized at a larger scale
Lake ice-out	Underwater temperature logger	May-July, depending upon elevation
Snowpack extent parkwide, MORA, NOCA, OLYM	remote sensing	March/April

Where is it measured?
EBLA: Current monitoring sites: Coupeville* (NWS Coop. Site – temp and precipitation), Oak Harbor Air Park* (full met.), Whidbey Naval Station (full met.) (*sites in park boundaries). No new sites recommended; other technical work groups may add micro weather stations for correlation with research projects
SAJH: Current monitoring sites: Friday Harbor airport (full met, outside park). Possibly add a site at English camp
FOCL: Current monitoring sites: Fire weather in park (temp and precipitation), Astoria Regional Airport (full met). Need input from other technical work groups on need for new sites.
FOVA: Multiple monitoring sites within 5 miles. No new sites recommended.
MORA, NOCA, OLYM: see following tables. With existing funds, only the first three priorities for each park will be selected.

Principal Investigators:
Kelly Redmond, Western Regional Climate Center, Mark Moore, USFS, Northwest Avalanche Control Center, Ted Bruehner, National Weather Service, Dick Bahr, NIFC, Scott Patee, NRCS, John Ray, NPS-ARD have provided their agency protocols for the national programs.

Barbara Samora is NCCN lead for compiling climate protocols. The MORA Bio. Tech, Rebecca Doyle will work with the above agencies as well as DOT to compile protocols for existing stations and work with other Networks to develop protocols for micro weather stations.

The OLYM Bio. Tech, Bill Baccus, is preparing draft protocols for the former EPA-GEM stations.
Bret Christoe is the data manager responsible for archiving/maintaining data in required formats, and working with the national programs to accomplish these tasks.

Schedule and Expected Interim Products:
FY2005: compile existing protocols into NCCN protocol document;
FY2006: get NCCN protocol document peer reviewed

Budget

FY2005: Technician support $30,400 (NCCN-VS)
Equipment purchase and maintenance $18,000

Bold text indicates highest priorities among proposed new sites.

MORA Existing Sites			**MORA Proposed Sites (listed in priority order)**			
SITE NAME	**Data Type**	**Represents**	**SITE NAME**	**Data Type**	**Represents**	**ESTIMATED COST**
Tahoma Woods	Full met.(station supports Air Quality Monitoring)	Low elevation west side	**Camp Muir**	Full met.	High elevation	Equipment: $9000 Installation $5000
Ohanapecosh	Full met. (RAWS)	Low elevation south east	**Carbon**	Upgrade to full met and automate	Low elevation North west	$8500
Longmire	Full met. array	Low elevation South west	**Cayuse Pass**	Upgrade to full SNOTEL site	Mid elevation East	Installation 12,000
Carbon	Currently just sporadic precip. and temp.	Low elevation North west	Summit	Temperature (Hobo)	High elevation	Installation $200- purchase with ONPS funds
Sunrise	Snow depth, temp, RH * will have wind, precip. by summer 2004.	Mid elevation North east side	Mowich	SNOTEL	Mid elevation, West side	$25,000
Paradise	Full met. and SNOTEL site	Mid elevation South west	White River	Full met.	Low elevation, North east	$25,000

SITE NAME	Data Type	Represents	SITE NAME	Data Type	Represents	ESTIMATED COST
Cayuse Pass	GOES site (temp, precip only)	Mid elevation East	Schurman	Full met.	High elevation	Installation $9500
			Longmire	automate	Low elevation South west	$9000

NOCA Existing Sites **NOCA Proposed Sites (in priority order)**

SITE NAME & PRIORITY	Data Type	Represents	SITE NAME	Data Type	Represents	Costs (Capital/Annual)
Marblemount	Full met.	Low elevation, west side	**Noisy Glacier (Baker)**	Basic Weather*	High elevation west slope	Capital cost $10K Maint. Cost $1K
Diablo Da	Basic met.	Low elevation-central	Washington Pass	Basic Weather*	High elevation East slope	Funded –DOT, NWAC
Ross Dam	Basic met.	Low elevation - central	**Silver Glacier**	Basic Weather*	High elevation Central	Capital cost $10K Maint. Cost $1K
Hozomeen	Full met.	Low elevation central	**Sandalee Glacier (Stehekin)**	Basic Weather*	High elevation west slope	Capital cost $10K Maint. Cost $1K
Stehekin	Full met.	Low elevation, East side				
Easy –Jasper	Currently temp. (SNOTEL?)	Mid elevation, West side				
Thunder Basin	Full SNOTEL	Mid elevation, West side				
Park Creek	Full	Mid elevation				

SITE NAME & PRIORITY	Data Type	Represents	SITE NAME	Data Type	Represents	Costs (Capital/Annual)
Ridge	SNOTEL	East side				

*basic weather includes all-year temperature (possibly hobo), snow depth, and radiation, summer wind speed and direction. Snow density measured in spring with glacier visit.

OLYM Existing Sites **OLYM Proposed Sites (top three sites Prioritized)**

SITE NAME	Data Type	Represents	SITE NAME	Data Type	Represents	Costs (Capital/ Annual)
Quinault	GEM site, full met. – may be replaced by CRN site	Low elevation West side/Interior	**Staircase -1**	Full met.	Low elevation Southeast/Interior	$6000/ $350
Lake Ozette	Full met.	Coastal, West side *	**Queets/Hoh Ridge - 2**	SNOTEL	High elevation West/Interior	$30,000/ $4,000
Lake Crescent	Full met. (needs addition of wind), lake depth & temp	Low elevation, North side *	**Elwha (Elkhorn/ Hayes R.S.) - 3**	Full met.	Mid elevation, East/Interior	$7,200/ $850 (Calibration/ Telemetry)
Hurricane (Waterhole)	GEM Site, full met. SNOTEL	High elevation** North side	Queets (after Naimen Research)	Full met.	Low elevation, West side	$6000/ $350
Hurricane (NWAC)	Full met.	High elevation **, North side	Anderson Glacier	Limited suite of Instruments	High elevation, East side/Interior	Unknown
Deer Park	GEM site, full met.	Mid elevation,	Dosewallips or	Full met.	Mid elevation East slope/Interior	$6000/ $350

SITE NAME	Data Type	Represents	SITE NAME	Data Type	Represents	Costs (Capital/ Annual)
		East side	Supplement Mt. Crag			
Hoh RS, GEM site, West Twin	GEM site, full met., Stream depth & temp	Low elevation, West side/Interior	Kalaloch	Full met.	Low elevation/Coastal West side	$6000/ $350
Forks/ Quillayute	Full met.	Low elevation, West side				
Sequim	Full met.	Low elevation, East side				
Cushman	Temp/precipitation	Low elevation, East side				
Elwha RS	Temp/precipitation	Low elevation, North side				
Port Angeles	Full met.	Low elevation, North side				
Quillayute	Balloon, 30,000 ft	High elevation, West side				
Mt. Olympus	Temperature	High elevation, West side				
Mt. Craig	SNOTEL	High elevation,				

SITE NAME	Data Type	Represents	SITE NAME	Data Type	Represents	Costs (Capital/ Annual)
		East side				